A MULTIVARIATE ANALYSIS OF EARNINGS FORECASTS
GENERATED BY FINANCIAL ANALYSTS AND UNIVARIATE
TIME SERIES MODELS

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Summary:

The study provides evidence on the relative accuracy of forecasts of
earnings generated from five sources including statistical models and
financial analysts. The statistical models were chosen on the basis
of their usage in recent studies in the literature. The results indi-
cate that the five types of forecasts are not significantly different
using a multivariate testing procedure.

A Multivariate Analysis of Earnings
Forecasts Generated by Financial
Analysts and Univariate Time
Series Models

There is a widespread belief expressed by both policy setting boards and empirical researchers that the use of forecasted accounting earnings as a measure of expected earnings power is of primary importance in investment decisions. The Financial Accounting Standards Board, a policy making body, recently reinforced this belief in their Conceptual Framework Project [11]. Many research projects that have investigated aspects of investment decisions, such as cost of capital, firm valuation, and the relationships between earnings and stock prices, have utilized forecasted accounting earnings as their measure of earnings expectations [2], [3], [4], [5], [12], [14], [17], [19]. A major question, however, exists as to the most appropriate source of these forecasts. Current sources widely available are various univariate time series models and financial analysts. Since these sources have both theoretical advantages and disadvantages, resolution of the question as to which source is most appropriate is largely an empirical issue.

Because of the difficulties of specifying a complete operational relationship between the forecast source and the investment decision, previous research that attempted to evaluate the competing sources of forecast information generally has focused on a stated or implied purpose of these forecasts. The purpose considered in this paper is forecast accuracy; this purpose also has been the subject of previous research ([7], [8], [9], [10], [13], [15], [23]).[1] Unfortunately, the results of these previous studies have been inconsistent and therefore inconclusive.

In addition, these studies generally utilized univariate statistical methods when the multiple model and multiple time period factors indicated that a multivariate hypothesis was being considered. Several problems are raised

by the use of univariate methods. First, the univariate approach to the research issue necessitates a larger number of tests of the null hypothesis rather than a single multivariate test. Since each individual test has an associated alpha error, there is a greater possibility that a number of these tests will reject the null hypothesis purely by chance. An additional problem relates to the assumption that univariate tests conducted at multiple time periods on the forecasted earnings for the same firms are independent. Since earnings variables for the same firm usually are highly correlated, the univariate tests may not be independent. These problems of combined reliability and statistical dependence may have affected the empirical findings and the resultant conclusions.

Previous studies that employed parametric statistics generally provided a comparison between the forecasts of financial analysts and those generated by naive models. They have not incorporated the more sophisticated time series models currently available. Nonparametric statistics generally do not consider the magnitude of the data. Therefore, previous research that used these statistics did not consider certain information available to the researcher.

Because of these problems and the inconclusive results, this paper provides additional evidence of the relative accuracy of forecasted earnings. Earnings figures considered are one quarter and two quarter ahead forecasts generated by each of four univariate time series models and by financial analysts. These five forecast models were selected because they are representative of models that have been considered in recent research efforts. These efforts, however, have not included an overall comparison of the relative accuracy of the five models.

The present paper provides this overall comparison based on a multivariate analysis of variance design (MANOVA). MANOVA was chosen

values for that particular model; and (c) perform diagnostic tests. The process consists of an iterative approach that excludes inappropriate models until the model and its parameter values that best fit the data are selected. Compared to previous time series analyses that were characterized by the individual consideration of many possible models, the Box and Jenkins process permits consideration of a much greater number of models in a more structured approach.

The first univariate model employed in this study, hereafter designated the BJ model, is a model individually identified and its parameter values estimated for each firm in the study. Thus, the BJ model for each firm is determined from the complete Box and Jenkins process. Since the model is determined from the consideration of a broad generalized model inclusive of all possible combinations of autoregressive and moving average models, the initial expectation might be that forecasts generated from an individually fitted model should be more accurate than forecasts generated from a model that was generally identified for all firms. However, the identification process is both subjective and costly. In addition, the identification of a model from a finite series of data points may not result in the model consistent with the underlying process generating an infinite series.

Because of these factors and observed empirical results, it has been suggested that a generally identified or premier model, with individual firm estimation of parameter values may generate forecasts that are equal or superior to those generated by the BJ model. If a single model form generates results that are comparable to an individually identified model, it would obviate the need to perform the subjective and costly identification process required for the latter model.

because it is a parametric test and thus more powerful for detecting population differences.

MANOVA also provides a comprehensive test. As a simple generalization of analysis of variance (ANOVA), it tests for a group (vector) of means rather than the more simple test for differences between means of a single variable. MANOVA does not ignore the statistical dependence that may result when forecasts made for multiple periods are compared for the same firms. Thus, MANOVA is considered the more appropriate test when multiple forecast methods are compared for the same firms for more than one time period.

In addition, the univariate models were reidentified and reestimated as each earnings figure in the test period was announced. Unlike most previous studies, then, this study utilized all earnings data that was available at the time a forecast was generated. It was considered more appropriate to reflect the additional earnings information in the univariate models since the financial analysts model did incorporate current information.

The paper is organized into four major sections. An analysis of the methodologies and results relating to prior research in the area is presented first in order to provide justification for the models chosen in the present study. The research design and statistical tests utilized in the present study then are presented followed by the empirical results. A summary of these results and the conclusions obtained complete the presentation.

I. PREVIOUS RESEARCH RESULTS

A. Univariate Models

The four univariate models are generated utilizing the time series process suggested by Box and Jenkins [6].[2] The complete process is a statistical technique that is used to (a) identify, in a parsimonious manner, the most appropriate model consistent with the apparent underlying process that generated the observed time service data; (b) estimate the parameter

It also would diminish the problem associated with the identification of a model from a finite series of observations.

The models proposed are (1) a consecutively and seasonally differenced first order moving average and seasonal moving average model (Griffin [15] and Watts [23]), (2) a seasonally differenced first order autoregressive model with a constant drift term (Foster [13]), and (3) a seasonally differenced first order autoregressive and seasonal moving average model (Brown and Rozeff [8]). In the notation used by Box and Jenkins, these models are designated as (0,1,1) X (0,1,1), (1,0,0) X (0,1,0) and (1,0,0) X (0,1,1), respectively. In this study, they are referred to as the GW, F and BR models.[3] The models are generally identified for all firms with individual firm estimation of the parameter values. Thus, only the parameter estimation portion of the complete Box and Jenkins process is used.

The different forms of a single or premier model form have been suggested based on the diagnostic tests incorporated in the Box and Jenkins process and also on predictive evidence. Watts, who initially suggested a premier model, based this suggestion on evidence that the average cross-sectional autocorrelation function (acf) could be modeled by the (0,1,1) X (0,1,1) model. Griffin also demonstrated that the average acf could be modeled by the (0,1,1) X (0,1,1) model. His suggestion also was prompted by the consistency of the distribution of the Box-Pierce statistic with the existence of white noise residuals.

Foster based his suggested model primarily on the evidence that one-quarter ahead absolute percentage errors associated with the F model were lower than these errors generated by the BJ model. However, Brown and Rozeff, Griffin, and Foster himself, note that the F model does not fit the data in that the model fails to incorporate a systematic seasonal lag.

Brown and Rozeff have attempted the most comprehensive study of the
relative merits of premier models heretofore. Their analysis included
the four univariate models that are the subject of the present study.
On the basis of the diagnostic tests, they concluded that the best fit
obtained by a premier model was from their suggested model. Furthermore,
their analysis of the mean absolute percentage forecast errors obtained
from one, five and nine-quarter ahead forecasts generated by each model
lead them to conclude that the BR model outperforms the F and the GW
model for all forecast horizons. They also concluded that their model
forecasts as accurately as the BJ model for the earlier forecast horizon
and outperforms the BJ model for the later forecast horizons. Acceptance
of the superiority of the BR model based on the observed results,
however, is questionable. Table 1 summarizes the comparison between the
BR and the BJ model, reported by Brown and Rozeff.

Table 1

Wilcoxon Test Statistic Comparison of
BR and BJ Models

One Quarter Ahead	Five Quarters Ahead	Nine Quarters Ahead
1969-1970 Not significant	1970-1971 Significant at .01	1971-1972 Significant at .
1971-1972 Not significant	1972-1973 Not significant	1973-1974 Not significant
1973-1974 Not significant	1974-1975 Significant at .05	1975-1976 Significant at .
1975-1976 Not significant	1976-1977 Not significant	

Note that the results are not significant for seven of the eleven
periods examined. In addition, for four of these seven nonsignificant
periods, the direction of the test results favor the BJ model. These
relationships, therefore, appear to be highly dependent on the particular
time period examined and do not appear to support the conclusions. A
potentially more serious problem, referred to earlier, is the statistical
dependence of the univariate tests. Brown and Rozeff sampled the same

firms for each of the different time periods. Thus, the forecast errors obtained in each of the different time periods are not independent of those of the other time periods and in fact, may be highly correlated. The statistical results, therefore, also would be highly correlated and may be misleading. The forecast accuracy comparison of the individually identified and the suggested premier models thus remains an unanswered question.

B. Financial Analysts Model

In addition to the four univariate model forecasts, the study included forecasts generated by financial analysts. The univariate models can be criticized in that they neglect additional publicly available information that may be potentially useful; financial analysts are not subject to this criticism. Rather, financial analysts have been criticized in that their analysis process may be too detailed and the additional cost incurred may not be justified.

Empirical results that support these assertions were provided by Cragg and Malkiel [9] and Elton and Gruber [10]. Both studies concluded that analysts' forecasts were not more accurate than forecasts based on earnings streams alone. The study by Brown and Rozeff [7], on the other hand, lead to the conclusion that financial analysts' forecasts were superior to forecasts generated solely from earnings data. These results, however, have been questioned by Abdel-khalik and Thompson [1] as being overstated, again due to their temporal nature. In addition, the technique selected by Brown and Rozeff, as discussed above, results in statistically dependent samples.

In the present study, the univariate models were included in order to assess the relative accuracy of these forecasts. Relative accuracy then may be useful in determining the existence of a premier model. The

results of the univariate models in comparison to the financial analysts

may be used to provide evidence as to whether the additional cost

incurred by financial analysts is justified. In addition, the evidence

provided as to the relative accuracy of forecasts generated from earnings

data alone and earnings data plus other variables may provide useful

information to the pending decision by the Security Exchange Commission

as to the desirability of management forecast disclosure.

II. RESEARCH DESIGN

A. General Hypothesis

The preceding sections highlight the recent attention given to the

question of whether a single generally applied univariate model provides

equal or superior forecasting results than an individual firm identified

model. An additional question is whether a univariate model provides

equal or superior forecasting results to those of a model that incorporates

more potentially useful information. These questions are incorporated

in the following null and alternative hypothesis.

Hypothesis:

> Ho: There is no difference in the average absolute percent
> forecast errors generated by each of five models (BJ, BR,
> F, FA and GW).

> Ha: There is a difference in the average absolute percent
> forecast errors generated by each of five models (BJ, BR,
> F, FA and GW).

Absolute percentage forecast error is specified as:

$$\left| \frac{A_{it} - P_{itn}}{A_{it}} \right|$$

where A_{it} = actual earnings per share for firm i in quarter t

P_{itn} = predicted earnings per share for firm i in quarter t
generated by model n

This metric was selected because it is a measure that establishes

relative comparability of forecast errors between firms that produce

The BJ model for each firm was both reidentified and the parameter values reestimated for each of the nineteen forecast periods utilizing a computerized program. This program determined the model, suggested by the autocorrelation and partial autocorrelation functions, that resulted in a white noise residual. This program was utilized because it reduced the time required by a more subjective analysis and its results have been demonstrated to be comparable to that analysis. (Hopwood [18]).

Since the BJ model could incorporate the suggested premier models, this meant that the diagnostic tests for the BJ model were superior for each of the forecast periods. The following comparison thus relates only to the three premier models. The parameter values for these models were reestimated for each of the 19 forecast periods. The diagnostic tests, however, were conducted only for the premier models estimated for the first forecast period, the first quarter of 1970.

These diagnostic tests included the autocorrelation check of the residuals and the calculation of the Box-Pierce statistic to test for white noise residuals. The autocorrelation check, similar to the results of other studies, strongly indicated that the F model failed to capture a systematic seasonal effect. This lack of fit was indicated for 38 of the 50 firms for which the model was estimated. The F model also performed less well when the existence of white noise residuals was tested. As indicated in Table 2, the F model resulted in the highest Box-Pierce statistic for 45 of the 50 firms. In addition, the null hypothesis that the residuals did not differ significantly from white noise residuals was rejected for 29 of the 50 firms. The F model thus fit the data less well than the BR or the GW models.

A difference in fitting ability was not readily apparent for these two models. The BR model resulted in the lowest diagnostic statistic in

26 cases; the GW model in 24. In only one case did the BR model result

in the highest statistic. Indications, however, were that the residuals

obtained from the BR model differed significantly from white noise

residuals for 9 of the 50 firms. The GW model resulted in the highes

statistic for slightly more firms but the residuals differed significantly

from white noise residuals in only 3 cases.

TABLE 2

The Results of the Box-Pierce Statistical
Test for White Noise Residuals

Model	Rejection of the Null Hypothesis		Relative Ranking of Statistics		
	.01 level	.05 level	Lowest	Second	Highest
F	20 firms	9 firms	0	5	45
BR	4 firms	5 firms	26	23	1
GW	2 firms	1 firm	24	22	4

B. Forecast Accuracy

A three factor (model, firm, and origin) MANOVA test was performed to test

for differences between models. The null hypothesis tested was:

$$\begin{vmatrix} e_{11} \\ e_{21} \end{vmatrix} = \begin{vmatrix} e_{12} \\ e_{22} \end{vmatrix} = \begin{vmatrix} e_{13} \\ e_{23} \end{vmatrix} = \begin{vmatrix} e_{14} \\ e_{24} \end{vmatrix} = \begin{vmatrix} e_{15} \\ e_{25} \end{vmatrix}$$

where e_{ij} represents the mean absolute percentage forecast error for an

i quarter forecast for model j. The alternative hypothesis was that the models

generated different forecast errors. The probability that a higher F-ratio

than the 1.2844 obtained would occur was approximately 0.25. Thus,

there was insufficient evidence to reject the null hypothesis.

Inspection of the cell means, however, indicated that, both the

mean and the variance of the forecast errors generated by the financial
analysts were lower than those attributable to each of the univariate
time series models. As indicated in Table 3, this relationship held for
both one quarter and two quarters ahead forecasts. Among the univariate
models, the BR model performed best. In fact, the mean error for this
model was the only univariate model mean less than the grand mean for
both quarter ahead forecasts.

TABLE 3

Comparison of the Means and Distributions of Forecast Errors Generated

	Model	Mean	Standard Deviation
One Step Ahead	FA	.3287	.9034
	BR	.4032	2.4811
	BJ	.4326	2.4112
	GW	.4433	3.4165
	F	.4855	2.8548
	Ungrouped Data	.4186	2.5532
Two Step Ahead			
	FA	.4131	1.0384
	BR	.4702	1.8793
	BJ	.5307	2.6460
	F	.5362	2.1198
	GW	.5365	3.2608
	Ungrouped Data	.4974	2.3120

Both the lower mean and the lower variance can be accounted for by the
fact that the univariate models produced a larger number and degree of
radical outliers than the financial analysts. This is demonstrated in
Table 4.

TABLE 4

List of Outliers > 10.0 By Model[e]

Model	One Step Ahead Outliers		Two Step Ahead Outliers			Total
BJ	14.0 17.25 17.52 66.0		10.92 11.52 13.4 23.35 72.65			9
F	11.57 16.4 37.8 74.2		13.8 20.36 37.9 40.67			8
GW	11.93 22.65 100.65		10.19 24.11 27.10 91.4			7
BR	15.65 77.0		14.97 19.0 47.55			5
FA	17.0		10.25 12.43 14.0			4
						33

The financial analysts generated only one radical outlier (> 10.0) for a one quarter ahead forecast and three for the two quarter ahead forecast. The largest outlier produced by financial analysts was 17.0 which was lower in magnitude than the largest outlier produced by the univariate models. In addition, 22 of the 29 outliers produced by the univariate models are accounted for by a one time radical swing in the adjusted earnings of two firms. In both instances, the financial analysts had anticipated these swings.

The number of radical outliers is low relative to the total observations. However, their effect on the means and variances, which weights each observation equally, may be high. Because this effect may not be a useful expression of disutility as represented by the error metric, an additional analysis was made that treated all errors in excess of five standard deviations as missing observations.[7] One hundred forty-two or 1.49% of the 9500 total observations thus were set equal to the mean value. Table 5 indicates the number of observations thus treated by model.

TABLE 5

Number of Observations Set Equal to the Mean Value by Model

Model	Number of Observations
F	35
GW	30
BR	27
BJ	26
FA	24

Following this treatment, the null hypothesis that there was no difference in the forecast error produced by the five forecast models again was tested. The F-ratio in the multivariate test of the equality of mean vectors was 1.3625. Since the probability of obtaining a higher F-ratio was approximately 0.21, the evidence was again insufficient to reject the null hypothesis.

As indicated in Table 6, the treatment of the small number of errors greater than 5 standard deviations as missing variables resulted in the means and the standard deviations of the five models being relatively close.[8] The BR model again appears to perform best among the univariate models and, in fact, performs better than the financial analysts for the one quarter ahead forecast. The univariate models which perform less well include the F model and the BJ model.

TABLE 5

Comparison of the Means and Distributions of
Forecast Errors - Outliers > 5σ Set Equal to Cell Means

	Model	Mean	Standard of Deviation
One Quarter Ahead	BR	.2541	.3868
	FA	.2607	.3923
	GW	.2617	.4261
	BJ	.2702	.3978
	F	.2720	.3874
	Ungrouped Data	.2637	.3982
Two Quarter Ahead	FA	.3013	.4259
	BR	.3153	.4408
	GW	.3214	.4539
	F	.3348	.4611
	BJ	.3363	.4616
	Ungrouped Data	.3218	.4489

IV. SUMMARY AND CONCLUSIONS

The results of the multivariate analysis do not support the rejection
of the null hypothesis. Indications then are that financial analysts and
each of the four univariate models generate forecasts that are not
significantly different in forecast accuracy when the measure of forecast
accuracy is conditional on the mean absolute percentage error metric.
These results hold for both analyses. The first analysis included all
forecasts. The second analysis, because of the potentially disproportionate
effect of outliers on the error metric, treated errors greater than five
standard deviations as missing variables.

The results further indicate that financial analysts forecasts
include a smaller number of radical outliers. Thus, in the relatively
small number of cases where radical swings in the earnings patterns of
firms occurred, analysts appeared to have anticipated and reacted to
these swings more quickly than the univariate models.

Based on these results, there is justification for the use of a premier

univariate model in empirical research instead of an individually identified univariate model. This is especially true of the premier model suggested by Brown and Rozeff. This model, as well as the other premier models considered, does not differ significantly in forecast accuracy from the more costly and subjective individually identified BJ model. In addition, the BR model appeared to react more quickly to radical earnings swings than the other univariate models.

When earnings are considered in a macro sense, the non-significant different in forecast accuracy and the cost differential provide justification for the use of a model that only incorporates previous earnings patterns rather than the more comprehensive financial analysts model. However, in a micro context, the fact that the financial analysts model anticipates and reacts more quickly to large earnings swings provides economic rationale for these forecasts. Policy board decisions as to the prospective requirement of forecasts may benefit from further research that more narrowly defines the areas for which more comprehensive models generate more reliable forecasts than univariate models.

A further consideration is that the smallest mean for all models and both quarter ahead forecasts exceeded a 25 percent error with a standard deviation of approximately 39 percent. This may indicate that the errors associated with earnings forecasts may be so great that forecasts from the present sources available may have little usefulness. This question, however, can be answered only through more comprehensive knowledge of the use of forecasted earnings by decision makers.

[1] For a comprehensive treatment of previous research in this area, see Abdel-khalik and Thompson [1].

[2] Since this process has been the subject of a growing amount of research, we will omit a detailed specification of the process. Interested readers are directed to Box and Jenkins [6] or Nelson[21].

[3] The F model differs from the model proposed by Foster in that the drift term is excluded based on evidence provided by Brown and Rozeff [7] that this term is not significant.

[4] The selection of an error metric assumes that a certain utility function is the most appropriate for evaluating alternative forecasting sources. This selection is arbitrary since little is know about the utility function of the users of earnings forecasts. In addition, a more complete analysis would require specification of the loss function specific to the investment decision.

[5] Because of the large sample size, the computer program was more feasible when a balanced design multivariate analysis was utilized. Since lengthier forecast periods were not available for all firms, the balanced design limited the analysis to a two quarter ahead forecast period.

[6] The selection of the value of 10.0 as an indication of a radical outlier was based on a visual analysis of the frequency distribution of the error metric.

[7] The standard deviations were computed by quarter based on all data except the radical outliers that were greater than 10.0. Thus, 33 of the 9500 observations were excluded for purposes of calculating the five standard deviations.

[8] The cell means also were calculated by excluding the observations treated as missing variables. This alternative approach produced virtually identical results but was not the procedure of choice since it did not provide an orthogonal analysis that facilitated computer operations.

APPENDIX

Listing of Sample Firms

Abbott Laboratories
Allied Chemical
American Cyanamid
American Seating
American Smelting
Bethlehem Steel
Borg-Warner
Bucyrus-Erie
Clark Equipment
Consolidated Natural Gas
Cooper Industries
Cutler - Hammer
Dr. Pepper
Dupont
Eastman Kodak
Eaton Corporation
Federal - Mogul
Freeport Minerals Co.
General Electric
Gulf Oil
Hercules, Inc.
Hershey Foods
Ingersoll - Rand
International Business Machines
International Nickel Co.
Lamsas City Southern Industries
Lehigh - Portland
Mead Corporation
Merck and Company
Mohasco Corp.
Moore McCormack
Nabisco, Inc.
National Gypsum
National Steel
Northwest Airlines
Peoples Drug Stores
Pepsico, Inc.
Rohm and Haas
Safeway Stores
Scott Paper
Square D
Stewart - Warner
Texaco, Inc.
Trans World Airlines
Union Carbide
Union Oil (Cal.)
U.S. Tobacco
Westinghouse Electric
Weyerhaeuser, Inc.
Zenith Radio

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